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A holistic, multi-level analysis identifying the impact of classroom design on pupils' learning

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ABSTRACT

The aim of this study was to explore if there is any evidence for demonstrable impacts of *school* building design on the learning rates of pupils in primary schools.

Hypotheses as to positive impacts on learning were developed for 10 design parameters within a neuroscience framework of three design principles. These were tested using data collected on 751 pupils from 34 varied classrooms in seven different schools in the UK. The multi-level model developed explained 51% of the variability in the learning improvements of the pupils, over the course of a year. However, within this a high level of explanation (73%) was identified at the "class" level, linked entirely to six built environment design parameters, namely: colour, choice, connection, complexity, flexibility and light.

The model was used to predict the impact of the six design parameters on pupil's learning progression. Comparing the "worst" and "best" classrooms in the sample, these factors alone were found to have an impact that equates to the typical progress of a pupil over one year. It was also possible to estimate the proportionate impact of these built environment factors on learning progression, in the context of all influences together. This scaled at a 25% contribution on average.

This clear evidence of the significant impact of the built environment on pupils' learning progression highlights the importance of this aspect for policy makers, designers and users. The wide range of factors involved in this holistic approach still leaves a significant design challenge.

1. Introduction

The multi-sensory impact of built environments on humans is a complex and current issue as illustrated by some recent papers. For example, Bluyssen et al. [1] highlight the importance of complex interactions in understanding indoor environmental quality (IEQ). They suggest the individual factors "… can cause their effects additively or through complex interactions (synergistic or antagonistic)" (p. 2632). Huang et al. [2] reinforce the interactive nature of IEQ, stating that "Physical environmental parameters are all interrelated and the feeling of comfort is a composite state involving an occupant's sensations of all these factors" (p. 305). Cao et al. [3] state that "Researchers have realised that people's discomfort is usually not determined by a single factor but instead reflects the integration physiological and psychological influences caused by many factors". Kim and de Dear [4] argue powerfully that there is currently no consensus as to the relative importance of IEQ factors for overall satisfaction.

Within the challenging context, this study set out to take a multi-dimensional, holistic view of the built environment within which humans (pupils in this case) live and work (study in this case) and sought to discover and explain the impacts on human well-being and performance (improved learning in this case).

The main aim of this study was *"to explore if there is any evidence for demonstrable impacts of school building design on the learning rates of pupils in primary schools"*. This is a powerful focus, given the availability of meaningful human performance metrics, the fact the pupils spend most of their time in one classroom and the societal importance of maximising pupils' achievement.

2. Theoretical approach

2.1. Overview of planned methodology

Studying the holistic impact of built spaces on people "in the wild" is a complex problem. So, this project draws particularly from

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the methodological experience of four key studies (which when mentioned below will be indicated as A, B, C or D):

- Zeisel et al.'s [5] study of the holistic impact of care facilities on Alzheimer's patients (A)
- Ulrich's [6] focused study on the impact of views of nature on hospital patients (B)
- Heschong Mahone's [7] studies of daylighting and its effects on pupil learning (C)
- Tanner's [8] study of school design (D)

The core element of this study was an expert assessment of diverse classrooms using an Environment–Human–Performance (E–H–P) model (A) that allowed the measurement, and so assessment, of built spaces and their human impacts. The survey instruments and "indicators" (A) were carefully trialled. The sample of schools was identified to provide a diverse sample of school types and sizes. Further diverse classrooms were identified within each school, in terms of their physical characteristics (orientation, level, size, etc). This provided the basis for the calibration of the E–H–P model. The theme of diversity in the spaces sampled is important to provide maximum opportunity for the impact of the physical factors to become evident (A, B, C). The decision was made to pursue a hypothesis driven approach so that the aspects of the model displayed logical, as well as statistical, relationships. This avoids the problem of strongly overlapping categories (D).

Alongside achieving diversity in the main independent variable being studied (the physical spaces), there were the issues of accessing consistent dependent variables across the whole sample and measuring (C) or controlling for (A, B) other independent variables. Focusing on the choice of dependent variables first, discussions with educational experts within Blackpool Education Authority were very valuable (C). The measures that are available for primary school pupils, and are consistently used across the UK, are rooted in regular teacher assessments of individual pupils against a National Curriculum Assessment Framework that defines "levels" of attainment. This data is, in the case of Blackpool at least, independently moderated via a sample of 25% of pupils. Levels of attainment for pupils are assessed for Reading, Writing and Mathematics. The effort and expertise that goes into these assessments far exceeds anything the project team could replicate and the measures are well known and understood by practitioners in the education and other sectors. Thus, the decision was clear that these measures should be used if they could be accessed.

The assessment of the impact of the built environment on pupils' performance is complicated by other significant independent variables. The risks to achieving the former were mitigated by the explicit inclusion (or controlling out) of the major additional factors (A, C) in the analysis. The main issue is variability amongst the pupils themselves across classrooms/schools, but was addressed (C) by focusing on progress within a given year, so self-calibrating for variability amongst the pupils themselves. This then opened the opportunity to use entry level of achievement/age which is thought to determine quite a large part of progress achieved and so would sweep in issues of individual ability and some effects of social economic background. Anonymous individual data was collected, including information on gender so that suspected gender differences could be tested. Other school factors are known to have an impact. Physical aspects will be factored in as measurable E–H–P variables, but this leaves elements such as the quality of the teachers, and the general school ethos (C). The identification of groups of pupils in classes and of groups of classes from discrete schools, provide potential ways to provide an analytical way into assessing these aspects using multi-level modelling (see below).

Bringing this all together, the combination of independent and dependent variables studied is summarised in Fig. 1.

2.2. Development of an environment–human–performance (E–H–P) model

An holistic perspective of the multi-sensory impacts of the built environment was operationalised via the hypothesis that the

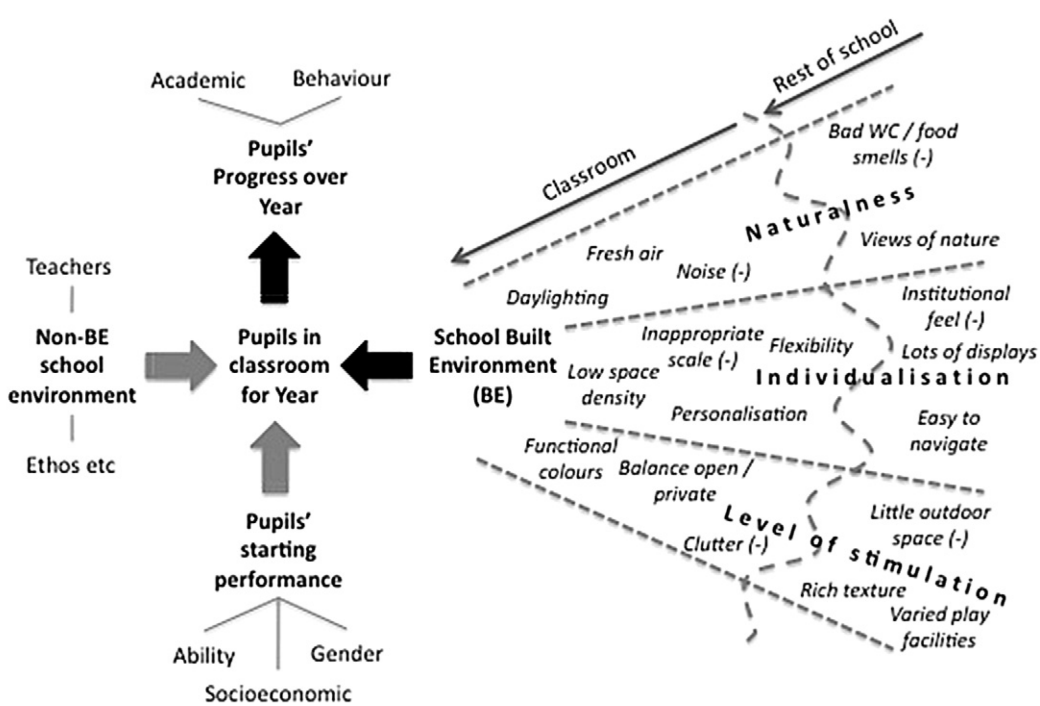

Fig. 1. Overview of HEAD research design (with examples of BE factors).